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The Berlin AEG Turbine Fitting Shop by Peter Behrens and Karl Bernhard

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ABSTRACT: By 1908 the architect Peter Behrens and the construction engineer Karl Bernhard both were commissioned by the AEG to make design proposals on the new turbine fitting shop. Both men were at that time already well known experts in their respective fields. Both, too, previously also had cooperated in such industrial projects like the AEG high voltage factory in Berlin-Wedding. Whereas Karl Bernhard was focussing on the turbine shop mainly as a steel structure being able to support craneways for extremely heavy loads, Peter Behrens was focussing more on the representation of AEG's technological and commercial leadership. Though both men were intensively cooperating and in the end came to quite a spectacular result they soon both would attempt to claim for priority banishing the respective counterpart into the secondary position of a mere consultant. An analysis of the building, however, might put more light on the impact of the contribution each one of them actually has made.

1 THE STRUCTURAL DESIGN OF A FUTURE ICON

Designed in 1908/09 by the architects Peter Behrens (1868-1940) and Ludwig Mies van der Rohe (1886-1969) assisting to him and not at least the engineer Karl Bernhard (1859-1937), the late AEG turbine fitting shop in Berlin-Moabit quite obviously ranks among the cornerstones of the Modern Movement. By numerous publications praising that it would represent a new synthesis harmonizing structural engineering and architecture it soon was reputed to be an icon of modern architecture. From the very start its distinct and rahter simplified monumental construction has shown the way to the principles of both the architectural and the structural design of spacious buildings for industry. However, already by the late 1920s it was only Peter Behrens who generally would be kept in mind as once being in this regard the true pioneer.

Such a still current view might rise the question to which extent Peter Behrens and Karl Bernhard each actually had contributed to this early manifestation of modern architecture. What in fact has appeared modern to their contemporaries? In the same way it might be asked whose basic ideas, those of the archtitect or those of the engineer finally would have dominated the design process and its result. Was their building at its time structurally modern or was it more likely representing modernity? Within the design process the architect and the engineer after all have seemed to meet as equal partners. Continueing the debate about the aesthetics of iron and steel structures which had commenced by 1889 but still was going on when the AEG commissioned the project, they aimend at almost common ideas. Though they got quite a lasting result in the end particularly Karl Bernhard, however, would not fully agree in every detail. Pleading for beauty deriving from suitability he contradicted Peter Behrens's opinion that monumentality essentially could be featured only by the domination of solid material but not by the disembodied transparence of vast windows apparently lacking any bearing capacity.

As the turbine fitting shop has remained almost unchanged and even its elongation executed by 1939 neither would have touched its appearance nor substantially its superstructure, an analysis of both the building itself and the purpose it is serving since, meanwhile however for Siemens Power Generation, might illuminate more precisely how much and where exactly Peter Behrens and Karl Bernhard each have influenced its construction. In this regard the whole structure offers a good many of evidence enabling something like an ‘archeological’ examination. Such an approach even would be supported by comparing the turbine fitting shop with subsequent buildings of almost the same functions like the late AEG fitting shop for heavy electric machinery in Berlin-Wedding or the late North British Engine Works diesel engine fitting shop. Though Peter Behrens and Karl Bernhard had cooperated once more again by 1910 in designing the German engine hall or the Brussels world exposition, on both these projects, however, they meanwhile were working apart from each other. So then again both of them accordingly would have had only to contract someone else as either an engineer or an architect for supplementary assistance.

Figure 1 : AEG turbine fitting shop, nave end with front gable and window flanked by one of the battered reinforced concrete corners *

2 AIMING AT PIONEERING ACHIEVEMENTS OF ADVERTISING APPEAL

In the course of summer 1908 Peter Behrens, whom the AEG had engaged already in the previous year as the general advisor for every artistic issue related to that company, was commissioned to draw up an architectural proposal for the new turbine fitting shop on the corner of Hutten and Berlichingen streets. The shop should cover a whole block of more than 200 metres length alongside Berlichingen street and almost 40 metres width. Whereas its front alongside the secondary Berlichingen street was to put opposite to a long row of multistorey tenement houses, the almost 30 metres high gable end of its nave dominating the major Hutten street should be the main feature of that new landmark. By its monumental appearance it was expected to become somewhat of a symbol highlighting both the technological and the commercial ambitions of the AEG.

Peter Behrens, however, would not only have to consider an architecture of rather an advertising appeal but in the same way to meet the demands of future operational procedures. In this regard the project already had been determined by O. Lasche, then the company’s chief production engineer. Above all the AEG meanwhile had needed additional space both for machining steam turbine components and then assembling them. While the AEG by 1904 when it just had acquired the premises of the late UEG or Union Electric Company, a subsidiary of the great Berlin machine tool builder Ludw. Loewe, merely had an output of some hundred turbines, its production meanwhile had considerably increased both in the number of units and their respective horsepower or size. Thus the old UEG turbine shop as designed by Theodor Rönn e.a., and erected 1895-7, could not keep pace anymore with the actual needs for space. Whereas its nave merely had a span of 18 meteres the nave of the new shop should get one of almost 26 meters.

Compared with the travelling crane of 25 tons load capacity in the old shop the pair of travelling cranes proposed for the new shop by covering a span of more than 23 metres jointly would be able to carry the fourfold.

Running at a speed of two metres a second or 7.2 kmh about 15 metres above the floor particularly these cranes together with the unusual range of the entire building considerably implied structural challenges. More than Peter Behrens it was to Karl Bernhard to meet them. Engaged as the constructional engineer some months later by autumn 1908 he additionally had to adopt both the architectural ideas of Peter Behrens and the demands of production technology as being predetermined by O. Lasche. Whereas Peter Behrens had preferred a multi facetted roof for the nave and in particular reinforced concrete as material for its about 10 metres hight gable end and the battered front corners just to get in appearance of massiveness, one of the main demands by O. Lasche, however, was transparency just to get an abundant incident of daylight everywhere into the interior of the shop. Though the front corners would appear like solid pillars supporting the roof, they are in fact nothing but rather light walls tapering of and therefore of even diminishing thickness.

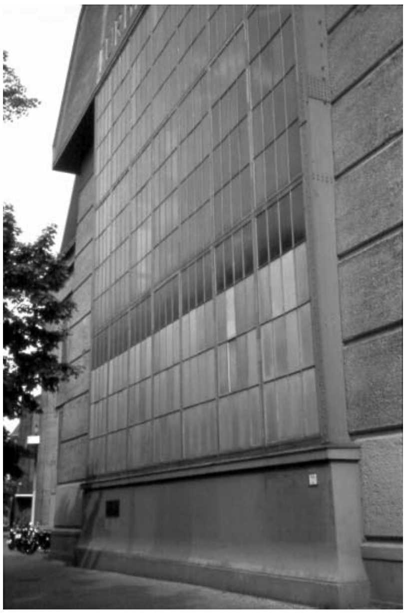

Figure 2 : AEG turbine fitting shop, footing with projecting base the nave front window

Figure 3 : AEG turbine fitting shop, longitudinal front with solid web stunchions

Daylight can enter into the shop through the large front window measuring 13.35 to 14.60 metres from the south as well as through the initially thirteen windows from the east. As it already was planned at the beginning by the 1939 elongation here eight windows of the same size finally were added. The northern front which should become similar to that in the south, however, never was built. So this side of the nave still nowadays is entirely closed by a solid wall. Whereas the steel casement frame of the face window is vertically encastered between the two battered concrete corners, however, those on the longitudinal front to the east have received the tilt of the corners. Here, on the other hand, the encastering solid web stanchions of the roof trusses, mounted on the pedestals projecting their common concrete footing, are representing both the vertical and the linear. As the appearance of the building would have to form an unified whole, all the footings, except that projecting the huge front window of the nave, are keeping throughout the same level.

The composition of the front corners, appearing like battered pylons or at least like pillars supporting the huge front gable of the roof, and the long row of the edgy steel stunchions following just behind like a colonnade might evoke the images either of an archaic temple in Doric order or the entrance of a temple from ancient Egypt. The alignment of the cornice with the stunchion fronts also would confirm such an impression. As the windows of somewhat more than nine metres width like both corners just below the cornice are inclining 1.20 metres backwards to the top, the upper parts of the intercolumnations thus are clearly shaded. In the same way the reinforced concrete wall of the multi faceted and tympan-like front gable is shading both pillar-like concrete corners flanking the tall front window in between. Albeit the tympan seems to project from both battered corners, in contrast, however, it is staying exactly in alignment with the wide surface of the window panes reflecting the sky. In this way the eye at first would focus on their shiny glass in the front centre and then on the roughly dressed tympan wall above it where the initials “AEG” and the signature ”Turbinenfabrik” both are engraved in gilded capitals also basing on Peter Behrens’s design.

Looking from Hutten street this architectural effect even would be increased by the projection of the entire nave end against the concrete wall on the short side of its two-storey aisle which itself even more appears rather modest because it is simply topped off with an almost flat and only slightly pitched roof. To accentuate both corners as supporting pillars horizontal steel bands were inserted into grooves moulded into their roughly dressed surface. The contrast between the heaviness of solid concrete and the transparent lightness of the vast window panes as well as the contrast between their expanse and the lineation of the steel bands, the window grilles, and not at least of the steel colonnade shaping its longitudinal side, eventually would give the building its monumental impact.

While Peter Behrens was recurring tho the classical patterns of Doric oder and by the combination of the tympan and the central window also was suggesting the image of a giant hammer itself representing industrial strength (Hoeger 1913), Karl Bernhard would have to focus more on the essentially structural issues. Above all he had to find a solution compromising the somewhat conflicting demands for an unrestrained movability of all cranes and those for a rigidity of the structure at any time keeping resistant to every kind of stress caused by the expected impact of their forces. Addinitonally Karl Bernhard had to provide an unrestrained incidence of light which meant that he had to reduce the measurement of every structural member to the essential minimum. Primarely aiming at a functional building on the other hand he could feel free not to pay too much heed to promotional aesthetics for public representation.

3 THE STRUCTURAL BODY UNVEILED

But when designing the longitudinal front of the two storey aisle even Ludwig Mies van der Rohe who at that time was collaborating with Peter Behrens as an assistant in the architect’s office (Heuser 1997/98), in this regard typically enough seemed to have left almost any artistic ambition out of consideration As this western longitudional front of the turbine shop merely would point to the inner courtyard he had primarely to take care of a sufficient daylight incident. In the end Ludwig Mies van der Rohe essentially would have to present reasonableness and suitability more than any advertising appeal. Thus he has designed a quite sober curtain wall of almost flushing glass and grey sheet steel surfaces, dominated by wide lattice windows and a continous apron in between covering the ceiling construction of the aisle.

Figure 4 : AEG turbine fitting shop, interior of the nave as viewed to the corner of Hutten and Berlichingen streets

The flat stunchions Ludwig Mies van der Rohe has suggested to protrude a little of the front to the factory site, not at least for its rhythmical subdivision and in order to mark every of its single bays, on the other hand are integral with its rigid portal frame construction as a whole. This solution therefore already has been suggested by Karl Bernhard. Whereas the ground floor has been provided with double-ply stunchions in order to carry the heavy loads and vibrations of the machine tools on the upper floor, he provided only single-ply struts there just to carry the rather light roof truss. By common clads their exterior, however, would present both of them like an unit.

Figure 5 : AEG turbine fitting shop, longitudinal front of the aisle

The girders of the portal frames on the ground floor are supporting a special ceiling construction that was designed by Karl Bernhard in each bay as a grillage of heavy I-beams consisting of single members in longitudinal direction and pairs of cross members with reinforced concrete cellar vaults in between. The double storey portal frames of the aisle which particularly in their lower parts on the ground floor are entirely stiffened, themselves are staying the main stunchions of the nave. These stunchions, each consisting of a pair of riveted plate girders coupled as lattice columns and rigidly jointed to the concrete foundation, on the other hand are carrying both the hinges of the multi facetted main roof truss and by special struts fitted right to each of them, the runway of the two 50 tons travelling cranes.

Both for the crown hinges and those at the stunchion bases on the opposite side of the nave to Berlichingen street Karl Bernhard has provided pinned joints, whereas he has mounted rather simple tangential rocker bearings on top of the rigidly jointed stunchions marking as a row the boundary between aisle and nave. Unlike those pinned joints this kind of a hinge only can transduce exactly vertical forces but no bending stress. The part of the proper roof trusses resting on the tangential rocker bearings has been designed as multifacetted lattice beam mainly composed of L and T bars. Although of the same design, however, the opposite roof trusses together with the stunchions there each are constituting a vertical member of a rigid portal frame with a hinged base. Both parts of the roof truss are connected with eachother on the neutralizing the thrust.

Because the lower part actually representing the stunchions within that rigid portal frame would emerge outside the nave, it was designed for aesthetical reasons as a massive riveted double-ply plate stay, whereas the struts in the interior directly fitted to the back and supporting the runway of the travelling cranes then again are realized as lattice structures. Quite appropriate to the model of the rigid roof frame struts featuring the colonnade of the longitudinal front to Berlichingen street, the cast steel saddles of their pinned base hinges have been moulded. Strikingly focussing the compressing stress on the rather thin pin clearly visible in the open clearance between each of their two ribbed pieces, and in this regard coinciding with the effect of the wide glass surfaces of the intercolumnitions, the base hinges almost give an impression of weightlessness.

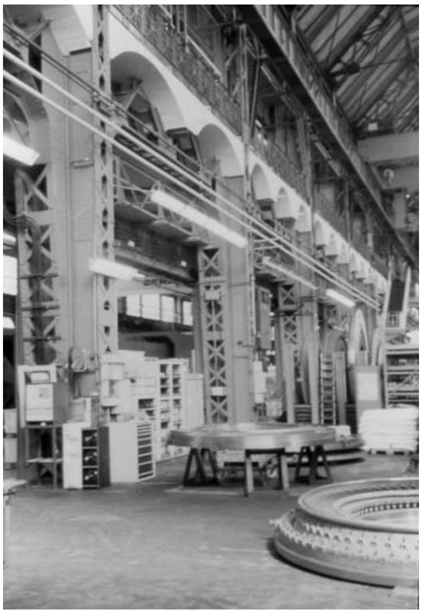

Figure 6 : AEG turbine fitting shop, view to the aisle gallery with reinforced concrete cellar vaulting and to the node of the roof truss tie rod

Figure 7 : AEG turbine fitting shop, view into the corner between the nave and the aisle

In this way the colonnade would offer a captivating contrast to the massy battered corners which then again merely are camouflaging the framework proper. Just behind their walls the runway of the travelling cranes is ending at a huge lattice stunchion on each side stiffend with steel plates, while the first of the three-hinged frames is interconnected with the steel encasement of the front window by both tie bars and crossbracings. A rather heavy plate girder is functioning here as a tie beam of the nave roof truss. Doing so it also carries the steel framing just behind the very thin concrete wall of the front gable which therefore, like the battered concrete corners beneath, is entirely independent of the steel construction of the framework proper. Almost invisible from the outside tie bars as well as crossbracings also are interconnecting the frames in the longitudinal extension of the nave. On both sides the craneways are reinforcing the stiffening effect. The rigidly jointed stunchions opposite to the window front, however, are interconnected by framed beams either embedding the reinforced concrete cellar vaults of the aisle or its roof.

4 THE SAME STRUCTURE BUT IN DIFFERENT CLADDING

While the foundations of the Berlin turbine fitting shop had been layed by spring 1909 and would be finishes already three months later, the construction of the steel framing by the Dortmunder Union, than the affiliate for bridge construction of the DeutschLux, the big German-Luxemburgian mining and metallurgical group, only would take five months more. So the entire shop could be put into operation by autumn 1909, just one year after Karl Bernhard had been consulted by the AEG for the first time.

Whereas Peter Behrens would be commissioned by the AEG in 1911 again with the design of a fitting shop for the company's electrical engineering branch, Karl Bernhard on the other hand would repeat his structural design for several times for different purposes but at almost the same size. During the years of 1909 to 1913 he accordingly received commissions for the structural design of three power plants in Strasbourg, Sosnowice, and Haidhof near Regensburg, but not at least of the late North British Engine Works fitting shop for heavy marine diesel engines nearby Glasgow, nowadays still used for the same purpose by Barclay, Curle & Co. Ltd. (Oglethorpe, RCHMS, 2005). All these buildings then again would get a multifacetted roof for their nave and an only slightly pichting roof for the aisle. Whereas the nave of the power plants would have to house the generating units, their aisle generally would have to encase the transformer and distribution switch bays. The nave of the Glasgow diesel engine shop on the other hand is used for assembly while the adjacent two-span and two storey aisle mainly is serving for the prepartional manufacture of the engine components.

Though this engineering shop is of almost the same measurement as the late AEG turbine fitting shop it is, however, rather different according to its appearance. As the Glasgow architect John Galt would not have to mind aesthetical demands to the same extent as Peter Behrens had been obliged to do, this building looks rather sober and primarily functional. Quite obviously there were two reasons why John Galt did not have to take much care about its advertising appeal. On one hand its site is part of the dock area in the industrial outskirts of the city so that there might have been less needs for considerations about its impact on the townscape. On the other hand the aisle in Glasgow is of almost the same size as the nave and the roof of the latter surmounting it only a little. The gable face also is less facetted and seems rather more of round shape. Albeit the framed roof trusses are facetted in almost the same way as in Berlin, the skylight here is an integral part of the roofing and to quite an extent the gable wall is occupied by the wide fanlight topping the huge frontwindow below.

Different to the Berlin fitting shop this window includes the glazed sliding gates and like all the other windows, too, it is flushing throughout with the external walls. In Glasgow those are merely thin yellow brick panels within a rather light steel framing, both always remaining visible. Thus they appear more like claddings than really load-bearing walls. As their surface is subdivided regularly crosswise by the narrow flanges of the wall framing members, they also lack any proper footing. Though the corners of the nave eah are much more rounded an more clearlythan those at the front end of the late AEG turbine fiing shop are based on quadrants, they look far less monumental. The projection of both the plate steel cornice bearing the front gable and the struts of the three-hinged nave frameword apparently supporting it on the longitudinal front like a draneway, is additionally emphasillzing that character of sover severity.

The main reason of such differences being rather conspicious then again would be to find in the structural peculiarities by which the Glaasgow diesel engine shop is dinstinguished from its Berlin counterpart. Though both buildings basically are structurally identical, however, Karl Bernhard in some regards would have altered his design for the three-hinged frames of the Glasgow shop. So he decided for instance to take articulated stunchions throuout on the ground floor. Thus one of the pinned base hinges of the nave frame stunchions would be set directly on ground floor level while the shorter one opposite to it would be set on the first floor of the nave where it then again would be supported by the outer one of the three articulated stunchions on the ground floor of the aisle. Altogether these three vertical members are supporting the main truss of the aisle ceiling so that on both floors there even more heavy machine tools could operate.

Except from the articulated stunchion being an integral part of the nave frame truss but resting on the first floor at its edge to the nave, however, the central and the outer stunchions each are stable and rather slender struts merely bearing the light truss of the aisle roof. This member then again is an integral part of the frame truss for the nave roof jointed to its counterpart by a pinned crown hinge. Different to the late AEG turbine shop, however, the Glasgow diesel engine shop never would need any kind of a tie beam or tie rod to neutralize the thrust of the roof truss. To carry the runways on both sides of the nave, both frame stunchions in a way are shifted aside from their vertical median line so that their contour seems like being cranked. This kind of cranking eventually also results in the projection of the upper parts of the stunchion frames out of the window surface on the longitudinal nave front.

5 A RECIPROCAL RELATIONSHIP

Albeit Karl Bernhard would not participate in the design for the new 175 metres long hall Peter Behrens by 1911 was commissioned by the AEG for the assembly of heavy electric machinery, it is quite closely related to his structural ideas. In particular the arrangement for the craneways is strikingly alike the solution he later would have realized for Glasgow. The craneway of late AEG fitting shop for heavy machinery in Berlin-Wedding, nowadays occupied by the Technical University there, on both sides is also supported by outward projections. Different to Glasgow, however, in Berlin the craneways are actually running on both the colonnade of ancon-like cranking stunchions and the brickwork of the side walls. This has made that the rather narrow window openings on the longitudinal front to Hussiten street in the west only are rising up to the craneway level whereas the wall until the cornice above it is entirely closed. Within each intercollumniation of the fifteen multifacetted roof frame trusses a pair of windows is encastered in the light steel framework of the therefore only thin panellings.

Whereas the longitudinal fronts of the shop are rhythmically subdivided by the outside flanges of the plate struts which, however, unlike with the late AEG turbine shop do not stand on accentuated or even only visible base hinges. It seems on the contrary that they would be posted like rigid pillars on their common battered brickwork footing. By this footing the whole building would look like standing on a bulwark, an effect that some more features even are adding to: the dropping of both Hussiten and Volta streets towads the corner of the building, the huge multifacetted front gable with the monumental steel characters “AEG” as they just previously also had been designed by Peter Behrens himself, and the five high but rather narrow windows embedded close together in their slightly projecting brickwork encastré.

Figure 8 : AEG heavy electrical machinery fitting shop at the corner of Volta and Hussiten streets

In contrast to the dominance of brickwalls over the window openings underlining its character of massiveness, the interior appears nevertheless rather bright. As the roof is almost entirely glazed daylight could incident actually in abundance and even more than it could into the nave of the turbine fitting shop. This effect might surprise though the single nave in Berlin-Wedding does not include an aisle by which additional daylight might incident but its longitudinal side wall in the east even would be wholly closed. Peter Behrens has increased this appearance of the interior by painting all wall surfaces in rather bright white contrasting to the dark but slender solid web trusses of the framing themselves visually restricted to the skylight area vaulting the undevided indoor space beneath.

Figure 9 : AEG heavy electrical machinery fitting shop, interior viewed to the southern front (Dec 1999).

Comparing the three early 20th-century Berlin and Glasgow industrial buildings it might be stated that it was quite obviously the rather close cooperation of both the architect and the engineer which in the end would have resulted in such pioneering structures. Particularly the ideas of Karl Bernhard, Peter Behrens, and to some extent at least of Ludwig Mies van der Rohe, too, would literally build the basis on which then again a fruitful, though sometimes also tense, cooperation could take place. Even beyond their cooperation proper the creative atmosphere of mutual inspiration would have continued as the case of the late AEG heavy electrical machinery fitting shop might have shown. Both Karl Bernhard and Peter Behrens were already widely acknowledged as being experienced in their respective field. So they were enabled to meet eachother as equal experts, albeit they both not at any time would be convinced of the merits being inherent in their respective ideas and design proposals.

Peter Behrens by 1908 and still by 1911 primarely was thinking in the terms of proportion and rhythm on which as an architect he above all would have to aim at whereas Karl Bernhrd primarely was imaging the possibilities to convert structural forces into both suitable and also visually convincing shape. His approach was tending to unveil the beauty of structural composition according to the properties of steel as his preferred material to neutralize or the impact of structural forces. Eventually Peter Behrens was aiming at the same achievements too, however, in more the conventional way of using stone and bricks for supporting and bridging members. By their apparently more solid character these construction materials seemed to him more appropriate to visualize meaning and not at least to express monumentality. On the other hand aiming more at suitability and rather an unconventionally abstract or at least generalized beauty of material properties to be put into shape, the almost naked steel framings by Karl Bernhard as well as the light or even scant glass and sheet steel dressings by Ludwig Mies van der Rohe eventually would prove being the more advanced.

REFERENCES

Anderson, S. 1999. Peter Behrens and a New Architecture for the Twentieth Century, Cambrige, MA: MIT Press

Behrens, P. 1919, *Kunst und Technik: Der Industriebau* 1(2), p. 176-235

Bernhard, K. 1910, Die neue Halle der Turbinenfabrik der Allgemeinen Electricitäts-Gesellschaft in Berlin; Zentralblatt der Bauverwaltung 30(5), p. 25-28

Bernhard, K. 1911, Die neue Halle der Turbinenfabrik der Allgemeinen Electricitäts-Gesellschaft in Berlin; Zeitschrift des Vereines Deutscher Ingenieure 55(39 and 42), p. 1525-1631 and 1673-1682

Bernhard, K. 1912, Der moderne Industriebau in technischer und ästhetischer Beziehung; Zeitschrift des Vereines Deutscher Ingenieure 56(29, 30 und 31), p. 1141-1147, 1185-1190, and 1227-1233

Bernhard, K. 1921, Dieselmaschinenfabrik in Glasgow; Zeitschrift des Vereines Deutscher Ingenieure 65(4), p. 85-88

Dicleci, C. 2000, Karl Bernhard. Die Durchdringung von Kunst und Technik: Deutsche Bauzeitung 134(6), p. 116-119

Heuser, M. 1997/98, La finestra sul cortile. Behrens and Mies van der Rohe: AEG-Turbinenhalle, Berlino 1908-1909; Casabella 61(651/2), p. 14-25

Hoeber, F. 1913, Peter Behrens, Munich: Georg Müller and Eugen Rentsch

Mies van der Rohe, L. 1924, Industrialisierung des Bauens; G. Zeitschrift für elementare Gestaltung 1(3), p. 1-13

Oglethorpe, M. 2005, Letter to the author 5 May including the records concerning the Barclay, Curle & Co. Shipyards with the late North British Engine Works at 739 South Street, Whiteinch, Glasgow: no.s C 47624, A 58924, A 74606, 38572, A 74592, and A 74597; Edinburgh: RCAHMS, The Royal Commission on the Ancient and Historical Monuments of Scotland